

Profitability of Feeding Holstein Calves Raw Whole Milk Versus Powdered Milk, Which Have
Varying Costs and Components.



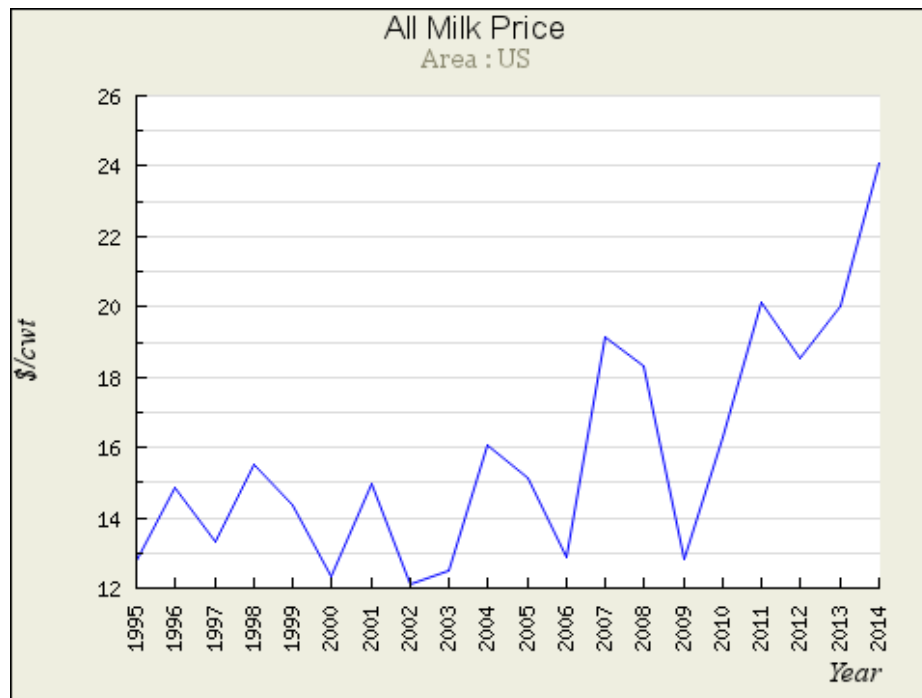
A Senior Project
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by
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INTRODUCTION

The dairy business has changed dramatically in last couple decades. It has been quite a roller coaster ride. It has become a game of utilizing the highs, and surviving the lows. One of the main reasons behind this is the milk prices; they have been inconsistent and unpredictable. Milk prices have ranged from \$12 per 100 pounds of milk to almost double that. As demonstrated below, there have been some drastic price movements throughout the last few years. This is a challenge for dairies because they don't know exactly what the future holds. From a milk producer's standpoint, the price matters. However, regardless of the price, they should want to produce as much milk as possible. The more milk produced, the higher the paycheck. Cows around the country are producing more milk now than they ever have. This is because of increased technology allowing each animal to be more efficient. It is also crucial to remember the importance of keeping costs as low as possible. Recent trends with the milk price have been favorable, but the input costs have also increased. Therefore, it is important to strive to be as efficient as possible.



Source: Brian Gould, *Agricultural and Applied Economics*, UW Madison, 2014

There is an ongoing trend of more efficient dairy operations today than there were in the past. There is a lot more milk being produced than there was ten years ago (USDA 2010). With numerous technological advances, dairies are increasingly becoming more efficient. New technology allows dairymen to cut costs as well as operate a more efficient operation. With higher input costs dairy owners can't slip up in just about any part of their business, and newer technology is certainly helping out tremendously. Every move is important, otherwise there may be some costly consequences.

For years dairymen have been trying to get the highest and best use of each animal. In the dairy business today, scientists and researchers have highly regarded that raising calves properly from the first few minutes they're born is very important. Van Amburgh states that the future of

the animal depends on how it is taken care of right after it is born (Van Amburgh 2013). It is more likely for the calf to have potential for a productive future if it is taken care of the right way immediately. Each calf is to be supplied with proper care to ensure good health. When a calf is completely healthy and provided with enough of the essential nutrients suitable for growth, that animal will be set up for a very productive life. During this stage of life, there are many changes in the calves' development. "The calf goes through significant developmental changes during the pre-weaning period and this development is directly linked to future productivity in first and following lactations" (Van Amburgh 2013). It is no guarantee that every animal will be utilized to their maximum capacity. There are other factors that the animal may endure during its lifetime, but it is one of the best methods to be set up in the future.

There are multiple different methods that dairies choose to raise their calves. It has been long debated in finding the best way. There are lots of arguments between feeding powdered milk versus feeding raw whole milk. The research and studies that have been done suggest that feeding high nutrient milk at high quantities is essential for growth and overall health. With this knowledge, one dairy named Rancho Sierra Vista Dairy decided to take a risk and feed raw whole milk. Based on the research, high nutrient diets at a young age leads to higher gains in weight. Although raw whole milk may be slightly higher in costs, the future herd fed with raw whole milk will be more efficient and productive.

METHODS

Rancho Sierra Vista Dairy is located in Visalia, CA. The dairy is newly acquired and has had some major revamping of the facilities in the past few years since it was purchased. One of

these facilities includes their calf raising operation. A lot of dairymen send their newborn calves to a specialized calf-raising ranch. However, in an effort to cut costs and vertically integrate, some dairymen have their own operation in which they raise the newborn calves themselves. Rancho Sierra Vista Dairy is one of those dairies. They have long considered making a couple small changes that might further advance their herd. This change could impact their upcoming animals to be even more efficient. This minor switch could have a major impact in the future. It consists of making an adjustment in what they are going to feed their calves from birth to about seventy to ninety days old. Before, they were feeding their calves a powdered milk product that they purchase regularly. In an effort to provide their calves with more nutrients, they are now going to feed the calves raw whole milk that is produced from the cows on Rancho Sierra Vista. Every day milk is produced and shipped to the creamery. With this switch in feeding, they will use a fraction of that milk to feed their calves. This means there will be less milk being sold for revenue, but they will be cutting costs since they will no longer be buying the powdered milk. This move is considered to be a big risk because these animals are the future milking herd. If it does not work out as planned, the dairy may suffer some underproduction from their cows. However, if it works out as planned, it will be worthwhile. This is an example of opportunity cost. They are willing to use some of the milk that they produce and sell for the use of feeding their calves. They will be eliminating the cost of buying the powdered milk, but it is actually more expensive to use the milk from the tank. However, they are willing to use a higher priced product for better expected results.

Rancho Sierra Vista Dairy had to make a few modifications to their milk barn in order to collect the fresh raw milk from the tank. They installed new pipelines to draw out the amount of

milk needed to fill enough bottles to feed the calves. These pipelines bring the milk outside to their bottle station located just outside of the milk barn. In that station, all of the milk is stored in a couple of large tanks. These tanks are designed to heat the milk up to the desired temperature prior to being filled in the bottles. The milk's temperature exiting the cow is roughly at the body temperature of the cow, which is slightly above one hundred degrees. The storage tanks outside bring the milk up to a little bit higher temperature at about 110-115 degrees. By the time the milk is bottled and delivered out to the calves, the milk will have dropped slightly in temperature and will be served at the appropriate temperature for feeding. Also, there are some different medicines that are added into the milk while it is in the tanks. The amount of medicine added to the milk is rationed depending on how much milk is in the tank. Below is a picture of these tanks.



As you can see, the milk enters from the pipes on the wall and exits through the hoses on the bottom. The milk is pumped out through the hoses and fills up the bottles. At the end of the hose is a “rake-like” device that allows for a faster way to fill multiple bottles. Pictured below is a Rancho Sierra Vista employee filling up hundreds of bottles. There will be a couple employees that drop off these bottles to the calves as they are driving.



At Rancho Sierra Vista Dairy, each calf is fed a gallon of raw whole milk each day. A bottle has a capacity of one half gallon, so there are fed these bottles twice a day. They are fed once in the morning and another time in the afternoon. This is method of feeding is used on most dairies. This is because it is less labor intensive. According to Perdomo and Santos, there are three different milk-feeding programs to Holstein calves. The first is called, “step method”. This refers to the calves being fed different amounts based on their age. The second method is called the “ad libitum milk feeding” is when the calves have a specific amount of time to feed on an unlimited amount of milk. This occurs twice a day. The third method is called “restricted milk feeding” (Perdomo and Santos 2011). This is the method used by Rancho Sierra Vista Dairy. As described above, the calves are fed two half-gallon bottles throughout the day totaling one gallon of milk fed per day. Perdomo and Santos state that the reason behind this is to get the calves started on a grain mix at the same time. Rancho Sierra Vista does exactly that. The calves are given small amounts of a grain mix at a very early age of about three days. They eat this grain so that their stomach starts to develop and adjust. However, the calves at this age primarily depend on the milk for their intake. As the calves get older, they transition into a more grain heavy diet. At the age of roughly 80 days, the calves are moved out of the hutches, weighed out, and then placed in a designated pen. From there they will only be consuming a grain mix.

Rancho Sierra Vista Dairy will be feeding a good amount of fresh raw milk from the tank daily in order to supply enough milk to fill the bottles. However, this amount of milk being drawn out every day depends on one other factor. On every dairy there is a group of cows that are either sick or have low quality milk. This group of cows is called the “hospital”. These cows are milked twice a day just like every other cow is. This group of cows produces milk that cannot

be sold to the creamery. This is because the cows contain antibiotics and other medications that require the milk of those cows to be withheld. The milk that is produced by the hospital cows are not picked up by the milk truck from the creamery. It is typically stored in different tanks to keep everything separated. Although this milk is not allowable to be sold to the creamery, it is absolutely suitable to use as feed for a young calf after it is pasteurized. There are no major nutritional differences in this milk compared to the normal milk. Most dairies that don't raise their own calves sell this milk separately to another party, usually a custom calf-raising ranch, at a given price. But there are some dairies that raise their own calves that use this waste milk daily to feed their calves, like Rancho Sierra Vista Dairy. Every day when the hospital cows are milked, that milk is collected, pasteurized, and ready to be fed. The amount of milk they get from the hospital cows depends on how many cows are in the hospital at that time. Rancho Sierra Vista does not have many cows in the hospital pen (normally less than 1% of the herd). Because of this, they do not have enough of the hospital milk to supply all of the calves on the facility. Now they must draw the remaining amount needed to be able to have enough milk to feed all of the calves.

Rancho Sierra Vista Dairy wants to monitor this transition to see if it is worthwhile. In order to do this, they must weigh every single calf at least two times to see if there is progress. A way to measure the calves' growth is called Average Daily Gain (ADG) in pounds per day. This measurement is calculated in the first 70-90 days of life. The calves are weighed shortly after they are born, also known as "in-weights". Then, the calves are weighed again (70-90 days later), and those are called "out-weights". With the in-weights and out-weights, it is possible to measure the ADG. Average Daily Gain also depends on how old the Holstein heifer is as well. Rancho

Sierra Vista Dairy has collected weights of a significant number of calves of both groups: powdered milk fed and raw whole milk fed.

In the early Fall of 2013, the first thing Rancho Sierra Vista Dairy did for this experiment was weighing their calves and recording their in-weights from day one of the calves' lives. From there the calves were fed the powdered milk product. The calves were already fed the powdered milk beforehand, but the employees first started keeping track of the weights in the Fall of 2013. It wasn't until roughly 70-90 days later when these calves get their out-weights recorded. When the out-weight is recorded, it is possible to calculate the ADG. The reason this was done was because they wanted to have a controlled group to see the difference of the calves when they eventually make the switch to raw whole milk. Rancho Sierra Vista Dairy made the official switch to raw whole milk on February 15, 2014. From that day forward, not one more calf was being fed the powdered milk product, but instead all of the calves were being fed raw whole milk. During the time of this experiment, initially there was going to be a test trial in which there would be a fraction of calves receiving the raw whole milk and the rest being fed powdered milk. This did not work out as planned because it would've required additional labor and additional costs. Therefore, Rancho Sierra Vista decided to make the full switch on February 15, 2014.

The reason why Rancho Sierra Vista Dairy wanted to do a test trial was, of course, to see the major differences in the two different groups and their growth. But they also wanted to do this because they wanted to have a controlled environment in which the two different groups experienced the same type of weather and climate. This way there wouldn't be any major differences if there was extreme weather. They were not able to make this possible because of

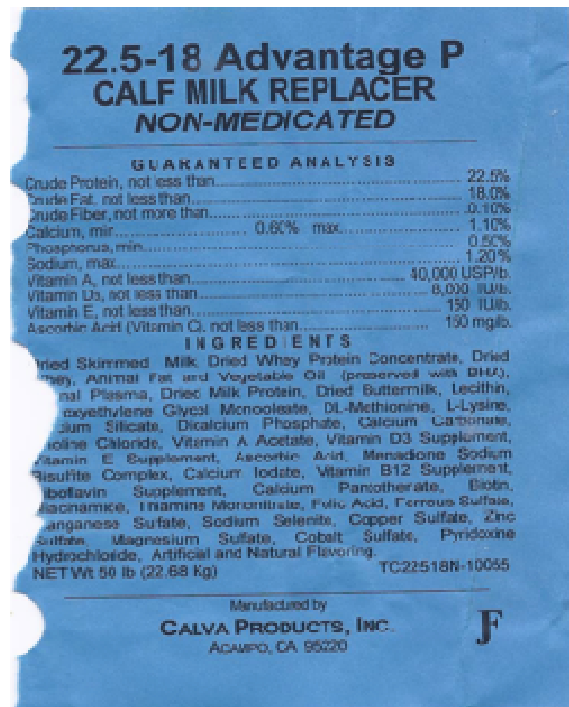
the reasons mentioned above. Although they made the switch all at once, there were no major weather patterns that would skew the experiment. The group of calves fed with the powdered milk did not experience a harsh winter this year, but instead a pretty dry and cool climate; there was never any extreme freezing. The other group being fed the raw whole milk has experienced warmer weather, which may impact the group slightly, but these weather conditions will not significantly alter the results.

HYPOTHESIS

Rancho Sierra Vista Dairy previously fed their calves a powdered milk formula, a milk replacer, named Calva Advantage Powder in previous years. This product is formulated to have a consistent balanced set of nutrients and components that are important for calf overall health and growth. This product is comprised of only the total dried components of milk, no water. Water is what makes up the main percentage of milk (on average it's approximately 87%-88%). The milk is dehydrated and leaves the components of the milk behind. Some of these components include: protein, butterfat, lactose, and ash (minerals). This powdered product is easy to use because all that needs to be done is add water. When applying the water to the powdered product at the suggested ratio, it becomes a good source of milk to the calf. The powdered milk is not the same as the milk that is produced daily on the dairy. Although the components can vary slightly from day to day, there are far more components in the raw whole milk. Below is a table displaying the composition of milk from Rancho Sierra Vista Dairy.

Rancho Sierra Vista	Milk Composition (%)
Water	87.51%
Protein	3.26%
Fat	3.65%
Lactose	5.02%
Ash	0.56%

The total amount of components in the milk are protein + fat + lactose + ash. Protein and butterfat are two of the major nutrients that are essential for calf raising in the earlier stages of life (Van Amburgh, Raffrenato, Soberon, and Everett 2008). The protein/fat ratio is something that is highly researched and tested. The more components in the milk, the more valuable it is. The total percentage of components in the milk for Rancho Sierra Vista Dairy adds up to be about 12.49% of their milk. From the total percentage of components in the milk, it is possible to calculate what percentage of those components protein and fat make up. The result of dividing the protein percentage, 3.35%, by the total components percentage, 12.49%, is 26.82%. This number is the percentage of protein in the total components. The same is true for the butterfat percentage. 3.65% divided by 12.49% equals 29.22%.



Rancho Sierra Vista Dairy was using the 22.5-18 Advantage Powder (pictured above) from Calva Products Incorporated. The number “22.5” represents the percentage of protein that is in milk replacer product, and the number “18” represents the percentage of fat. There are also other components at very small amounts. Since there is no water in the product, those percentages are the actual makeup of the dehydrated product. In comparison to the milk produced by Rancho Sierra Vista Dairy, the protein/fat percentage ratio of the powdered product is much lower. Below is a table that shows a comparison of the protein/fat component percentages.

Component Type	Rancho Sierra Vista	Calve Advantage Powder
Protein	26.82%	22.5%
Fat	29.22%	18%

As displayed, it is clear that the raw whole milk from Rancho Sierra Vista Dairy has higher component percentages. Because of this, Rancho Sierra Vista Dairy has eliminated the Calva Advantage Powder product and has started feeding their calves with raw whole milk that they produce daily. Although there are no problems with the powdered product they are using, they are looking into further advancing the growth of their calves. The calves will be receiving about 7% more protein in their new rations. Protein is essential in the early stages of growth, and early growth is important for the future of the animal (Van Amburgh, Raffrenato, Soberon, and Everett 2008).

With higher component percentages in their milk compared to the powdered milk, they expect the calves will grow faster. The reason why the managers at Rancho Sierra Vista Dairy want their animals to grow faster is because they want to get the maximum utilization of each animal. The faster the calves grow, the earlier they will be ready for breeding when they are heifers. When the heifer is ready to give birth to a calf, results in the beginning of their milk production. If the heifer grows according to their expectations, that animal will be used very efficiently for milk production.

According to multiple sources, the more nutrient rich milk fed to calves, the better the results. Researchers such as Van Amburgh, Raffrenato, Soberon, and Everett state that “what the cow would normally provide to the calf is the appropriate combination of protein and energy required by the calf” (2008). What they mean behind this statement is that whole milk is the natural way of feeding for a calf because it is high in protein and butterfat, also known as energy. Milk replacers, such as Calva Advantage, contain a sufficient amount of nutrients for calf growth, but do not use the maximum potential of whole milk. As mentioned above, the Calva milk replacer is a lot lower in component percentage than raw whole milk. The calf does not suffer when it is fed a milk replacer, it is just not being used at its full potential for growth. Van Amburgh, Raffrenato, Soberon, and Everett simply call it a “maintaining” of energy levels in the milk replacers (2008). The calves consume a higher caloric ration when they are fed raw milk. Perdomo and Santos (2011) would agree with Van Amburgh, Raffrenato, Soberon, and Everett (2008) on this subject. They say that calves need to be fed with a high source of protein. This could either be a very high quality milk replacer or raw whole milk. Their suggested percentage of protein in the milk being fed to the calves is 28% (2011). This works perfect for Rancho Sierra Vista Dairy because they produce milk with a higher protein percentage that’s close at 26.82%. Although there can be slight variations in the protein percentage in the milk that produced daily, it stays fairly constant if there are no major adjustments to the feed ration to the cows.

There are some researchers that believe that feeding higher quantities of milk in general is the best way to provide higher components to the calves. A group of researchers named Khan, Weary, and von Keyserlingk state that “greater nutrient supply through increased amount of milk

appears to improve immune function and long-term performance of heifer calves” (2011). Khan, Weary, and von Keyserlingk suggest to feed more milk so that the calf consumes more nutrients. Perdomo and Santos also agree with this concept (2011). They believe that the amount of milk fed to the calves should be doubled by the time they reach 4 weeks of age. Rancho Sierra Vista Dairy is not doing exactly what these researchers suggest. However, they are, in a way, using this concept in their own way. When they were feeding the Calva Advantage milk replacer, they were feeding two half-gallon bottles a day. Since making the switch to raw whole milk, there are feeding the same amount of milk - one gallon per day. The volume of milk being fed remained constant but the amount of quality components being consumed are largely increased. In other words, instead of feeding double the amount of milk, they will compensate for that by feeding higher component milk. Rancho Sierra Vista will not be feeding any more milk. The reason why Rancho Sierra Vista decided to keep the same feeding systems is because they don’t want to create more labor-intensive jobs. If they made another change it would be hard to adjust and it would cost a lot more in labor costs. That is why this style of feeding calves is the most popular procedure throughout the majority of dairies in the country. Feeding larger volumes of raw whole milk in the future might be something Rancho Sierra Vista Dairy will consider.

There are three major reasons why feeding raw whole milk instead of a milk replacer is worthwhile. These three things are: breeding heifers at an earlier age, heifers starting milk production at an earlier age, and higher milk production. All of these things are long term effects taking place about two years after the calves are fed the raw milk. That is why making this switch is risky. Rancho Sierra Vista will not be able to see these three things for a long time. If it does not work out as planned, the dairy will likely not see the results that they were expecting.

However, if it does work out as planned, the cows will have a productive and more efficient future.

There are multiple sources suggesting that it will indeed work when calves are started on high nutrient milk from the start. The high nutrient milk will allow the calf to grow faster (higher ADG, Average Daily Gain). High ADG means that the calf will be set up for potential in the future. According to Khan, Weary, and von Keyserlingk, “higher growth rates observed early in life are associated with reduced breeding age and higher milk-yield when the calf matures” (2011). Reduced breeding age is very important. Typically, heifers start getting bred at a certain age because that age generally represents the size of the animal. These animals are bred when they reach a certain size because of the reproductive development. But when the calf is growing faster, it will be larger at a younger age. Therefore, the heifer will be bred earlier. When this occurs, the dairy becomes a lot more efficient in more ways than one.

When the heifer is bred at an earlier age, it is likely that it will begin milking at an earlier age. This is very critical in the milk production because it increases the number of cows being milked, which therefore means more milk to be produced and sold. Not only does higher ADG's as a young animal allow the calf to start milking earlier, it has a very good chance that it will produce more milk in its future lactations. According to Van Amburgh, Raffrenato, Soberon, and Everett, pre-weaning growth rate (ADG) and first lactation milk yield have a strong correlation (2008). For one pound of growth there will be one thousand pounds of milk that is produced by that animal (Van Amburgh, Raffrenato, Soberon, and Everett 2008). Khan, Weary, and von Keyserlingk think similarly. They say that “pre-weaning ADG has the greatest correlation with

first-lactation milk production” (2011). Then, they figured out something almost exactly like Van Amburgh, Raffrenato, Soberon, and Everett did, only using different units. “Approximately 25% of the variation in first-lactation milk production could be explained by pre-weaning average daily [bodyweight] gain; for every 0.1 kg increase in pre-weaning average daily gain, heifers produced 107 kg more milk during their first lactation” (Khan, Weary, von Keyserlingk 2011). High nutrient intake at a young age plays a significant role in the growth of the animal and that leads to a bright future in milk production.

COSTS

The major cost that Rancho Sierra Vista Dairy is experiencing is the decision to feed raw whole milk from the tank instead of the Calva Advantage powdered milk product. The reason why this is a big deal is because they are taking what they sell and using it to feed their animals. This is an example of an opportunity cost. This is because they could continue to feed the powdered milk and sell 100 percent of the milk they produce. Instead, they are no longer using powdered milk and using a fraction of the milk they produce daily to feed about 1,200 calves. The amount of milk used for feed is a significant amount. This means that they could’ve made that much more money by selling that amount. However, at the same time, they are eliminating the cost of the Calva Advantage product. Even though there is a price difference, Rancho Sierra Vista Dairy still considers this to be a smart move because of the component differences that result in more potential growth. In their situation, it is worth it to supply their calves with a higher nutrient product to sustain higher growth, even though raw milk may be slightly more expensive to feed. The following equations and simulations are strictly the costs for feeding powdered milk and raw whole milk. Rancho Sierra Vista Dairy also feeds a small grain mix. The

costs of the grain mix are excluded from the total cost functions because they remained constant throughout the experiment.

As mentioned earlier, there are a lot of fluctuations in the milk market. In the past decade, dairymen have experienced extreme highs and extreme lows that caused a shake up for a lot of dairies. Currently, the milk price is at a favorable price for dairymen at about 23 dollars per 100 pounds of milk. More dairymen are making money compared to a few years past. Since the milk price is at an above average price, Rancho Sierra Vista Dairy is feeding their calves a fairly expensive product. The timing of their switch didn't necessarily come at the perfect time. However, if the market acts like it normally does, the future milk price will eventually be lower than it is now. If that's the case, Rancho Sierra Vista will be feeding cheaper whole milk. This makes it a little bittersweet for them because they want high milk prices to sell their milk, but at the same time they don't want their feed costs to be extremely high.

The price of the powdered milk moves with the fluid milk market prices in terms of the general trends. When fluid milk prices are higher, powdered milk will be more expensive; when fluid milk price is low, the powdered milk will also be low. The powdered milk product used before at Rancho Sierra Vista Dairy was supplied in 50-pound bags. In December of 2013, the price for this 50-pound bag of Calva powdered milk was \$62.05. In February of 2014, the price was slightly higher at \$64.55. In order to provide the calves with one gallon of milk per day (the feeding system of Rancho Sierra Vista), they must mix the powdered milk with water to create milk feed given the suggested ratio. With this ratio, the calves are being fed 1.13 pounds of the powdered milk, also known as dry matter (DM) or the solids in the milk such as lactose, protein,

fat, and ash. The number 1.13 does not include the weight of the water that is added. Since each calf is being fed 1.13 pounds of dry matter per day, it is possible to figure the number of calves that can be fed per 50-pound bag of powdered milk.

$$\frac{50\text{-pound bag}}{1.13 \text{ pounds DM fed per day}} = 44.247$$

The result of the equation above represents the number of calves that can be fed with a single 50 pound bag of powdered milk. Almost 45 calves can be fed with just one bag that costs \$64.55. The cost to feed a single calf can be solved by dividing the price of the bag of powdered milk by the above result: 44.247 calves.

$$\frac{64.55 \text{ dollars}}{44.247 \text{ calves}} = \$1.459$$

The number “1.459” represents the cost of feeding a single calf per day (\$1.459/calf/day). This cost number came from the higher price that took place in February. This price is not constant; it fluctuates just like the fluid milk market does. Therefore, \$1.459 per calf per day was not always the exact number of cost per day in the previous months and years Rancho Sierra Vista Dairy fed this product. In fact, 1.459 is probably on the higher end of cost per day. In December of 2013, the price was about two dollars cheaper at a price of \$62.05 per 50-pound bag. These prices took place during the time that the fluid milk price was higher than normal. In years past when the milk price was lower, these powdered milk bags were also probably

significantly lower. If the milk price is 20% lower than it is now, it would result in 18 dollars per 100 pounds of milk. If the bags of powdered milk experienced the same trend, they would have a cost of about 50 dollars. Although, it is unlikely that the price will ever go that low for powdered milk, that dramatic drop in prices can greatly affect the cost to feed calves. If the bag of powdered milk costs 55 dollars for a 50-pound bag, the cost of feeding a single calf will be \$1.24 (assuming the calves will still be fed 1.13 pounds of solids). If the price was 60 dollars, the cost would be \$1.35 per calf per day. The range in feeding costs per calf heavily depends on the price of the powdered milk.

Rancho Sierra Vista Dairy has a maximum capacity of 1,256 calves on their facility. Although this is a lot of animals, there is not always that many calves in the hutches. This is because they always need to have extra space for the newborn calves incoming every day. About once or twice a month, the employees of the dairy weight out the calves when they reach a certain age. This creates more space for the incoming newborns. On average, there are between 1,000 and 1,200 calves being held in hutches. The numbers may vary depending on the time of year. Because of this, the amount of milk required to feed all of the calves depends on the number of calves. Below are a couple equations showing the amount of bags of powdered milk required for a given number of calves to feed.

$$\frac{1,000 \text{ calves}}{44.247 \text{ calves per 50 lb. bag}} = 22.60$$

OR

$$\frac{1,200 \text{ calves}}{44.247 \text{ calves per 50 lb. bag}} = 27.12$$

If there are 1,000 calves being fed powdered milk daily, it would require almost 23 bags. If there are 1,200 calves being fed milk daily, it would require almost 28 bags. When the amount of product needed is computed, it is possible to figure out the total cost of feeding all of the calves per day. Simply multiply the number of bags need by the price of the 50-pound bags.

$$1,000 \text{ calves: } (22.6 \text{ bags powdered milk}) \times (\$64.55 \text{ per 50 lb. bag}) = \$1,458.83$$

$$1,200 \text{ calves: } (27.12 \text{ bags powdered milk}) \times (\$64.55 \text{ per 50 lb. bag}) = \$1,750.60$$

The above equations represent the total cost to feed the given number of calves per day. There is almost a 300-dollar difference in the total cost between the lower capacity and the higher capacity. The equations above also assume that the price is \$64.55, which is also on the higher end of prices. If there are lower prices in the powdered milk, there will be lower daily feed costs.

$$1,000 \text{ calves: } (22.6 \text{ bags powdered milk}) \times (\$60.00 \text{ per 50 lb. bag}) = \$1,356.00$$

$$1,200 \text{ calves: } (27.12 \text{ bags powdered milk}) \times (\$60.00 \text{ per 50 lb. bag}) = \$1,627.20$$

There is not as significant of an impact when the price is slightly lower, but it definitely reduces the total cost numbers. The “total cost per day” equations are consistent with the “cost per calf per day” equations mentioned earlier. There are two different ways in which to configure the total costs: on a per bag basis or on a per calf basis. No matter which way to approach computing the total cost, they will be very accurate in the final number. For example, take the cost per calf per day number, 1.459, and multiply it by the number of calves, 1,200. This results in a number very familiar: \$1,750.8. After exploring numerous possibilities and scenarios, it is safe to say that Rancho Sierra Vista Dairy has total cost number that can range from \$1,300 to \$1,800 when feeding the Calva Advantage powdered milk product.

When Rancho Sierra Vista Dairy officially eliminated powdered milk, they also eliminated all of those costs mentioned above. It is always a relief to cut costs, but in this situation, Rancho Sierra Vista Dairy is creating slightly higher costs due to them feeding a more expensive feed - raw whole milk. Also, however much milk they need to feed their calves is not being sold for revenue, therefore another aspect of the opportunity cost. The difference in costs is minor, but the difference in the benefits resulting from feeding higher component milk could be major. The cost equations that were solved earlier were broken down in two separate ways, total cost per day and cost per calf per day. To keep things consistent and easily comparable, the upcoming equations will be solved in the same way.

The cost for raw whole milk uses different units than for the powdered milk. With powdered milk, the costs could be solved by the price of each 50-pound bag. The unit used for

the milk price is “per 100 pounds of milk”. For raw whole milk, the cost for feeding their calves is exactly what the market price is during that period of time. Currently, the milk price is about 22 dollars. In the previous four months, Rancho Sierra Vista Dairy has averaged \$22.11 for their milk price. With this number, it is possible to figure out what the costs will be to feed the calves at Rancho Sierra Vista Dairy.

There are two different approaches to find out the costs to feed the calves raw whole milk at Rancho Sierra Vista Dairy. The first approach is based on fluid milk. On average, one gallon of raw whole milk weighs about 8.6 pounds. This number can vary slightly due to the amount of components in the raw milk. However, for this experiment it is assumed that one-gallon of raw whole milk weighs 8.6 pounds. At Rancho Sierra Vista Dairy, each calf receives exactly one gallon of milk daily (two half gallon bottles). This makes it very easy to find out the amount of milk that needs to be drawn out of the tank to feed all of the calves as well as the costs. The equation displayed below shows how many calves can be fed with 100 pounds of milk (\$22.11).

$$\frac{100 \text{ lbs. raw whole milk}}{8.6 \text{ lbs. per gallon of raw whole milk}} = 11.627$$

The above equation converts 100 pounds of milk into gallons. 11.627 represents the number of gallons in 100 pounds of milk. In other words, 11.627 calves can be fed by 100 pounds of milk since they are fed one gallon per day. This also means that it costs \$22.11 to feed 11.627 calves because that is the price of 100 pounds of milk.

$$\frac{\$22.11 \text{ per } 100 \text{ lbs. raw whole milk}}{11.647 \text{ calves}} = \$1.898$$

The result of this equation, 1.898, represents the cost per calf per day being fed one gallon of raw whole milk. This number is definitely higher than the cost per calf per day being fed powdered milk. There is a 45-cent difference in feeding a single calf per day when the price of powder is \$64.55. In order to find the total cost using the individual calf per day cost, multiply 1.898 by the number of the calves being fed. Similar to earlier computations, there could 1,000 calves or up to 1,200 calves. The total cost can range from 1,900 dollars to almost 2,300 dollars, depending on the number of calves in the hutches.

$$(1.898 \text{ cost per calf per day}) \times (1,000 \text{ calves}) = \$1,898.00$$

$$(1.898 \text{ cost per calf per day}) \times (1,200 \text{ calves}) = \$2,277.60$$

The second approach for raw whole milk costs is in terms of the dry matter intake. When the calves were being fed powdered milk, they were receiving 1.13 pounds dry matter of milk solids in their daily ration. Now that they are being fed raw whole milk, they are consuming 1.06 pounds of milk solids (Lindeque). This is because the raw milk is significantly higher in components. In the 1.13 pounds of dry matter being fed from the powdered milk, the calves are receiving 2,319 calories (Lindeque 2014). On the other hand, the calves are being 1.06 pounds of dry matter solids from the raw milk, and they are consuming 2,514 calories (Lindeque 2014).

This means that with less dry matter content being consumed, they are still getting more valuable nutrients.

Rancho Sierra Vista Dairy produces milk that contains high component percentages. As mentioned earlier, their milk has an average of 12.49% solids. The number 12.49 will not be constant on a daily basis. This number can vary slightly because of numerous different reasons. The remaining 87.51% is water. Since the milk has 12.49% solids, there will be 12.49 pounds of solids in 100 pounds of milk. Similar to the fluid milk cost breakdown, it is possible to find the number of calves that can be fed with 100 pounds of milk.

$$\frac{12.49\% \text{ DM solids}}{1.06 \text{ pounds DM fed per calf per day}} = 11.745$$

The number resulted represents the number of calves that can be fed from the 12.49 pounds of solids in 100 pounds of milk. In terms of dry matter, the number 11.745 is not equal to the number solved earlier from the fluid milk breakdown, 11.627. Although it is very close, the numbers differ slightly because of some rounding and also because of the many variables that are not always constant. One example is the percentage of solids in milk. The solids in milk sway one way or the other every day. In the example, 12.49 is an average number from previous milk tests. Although there are some variations, Rancho Sierra Vista Dairy will always try to feed their calves 1.06 pounds of dry matter solids per day; that number stays constant unless there are changes to the rations. With the knowledge that 12.49 pounds of solids can feed 11.745 calves,

what is the amount needed to feed all 1,200 calves? The equation below demonstrates how much milk will be needed.

$$\frac{1,200 \text{ calves}}{11.745 \text{ calves per 100 pounds milk}} = 102.17 \text{ units}$$

Note: 1 unit = 100 lbs. of milk

The above equation results in 102.17 units of milk. In other words, Rancho Sierra Vista Dairy needs to use 10,217.11 pounds of milk (or 1,188 gallons) to feed all 1,200 of their calves. To find out how much this costs is quite simple. The price Rancho Sierra Vista is getting paid for each unit of milk is \$22.11.

$$(102.17 \text{ units of milk}) \times (\$22.11 \text{ RSV milk price}) = \$2,258.97$$

Assuming Rancho Sierra Vista Dairy's milk price remains at \$22.11, the total cost to feed 1,200 calves will be \$2,258.97. This number is very similar to the total cost from the fluid milk analysis, \$2,277.60. With these two total cost simulations, it is safe to assume that Rancho Sierra Vista Dairy has a total cost ranging from \$2,200 to \$2,300.

Earlier there was a fluid milk analysis breaking down the cost of an individual calf per day. That cost equalled \$1.898 per calf per day. If we take the total cost result from above, divide it by the number of calves, it will give the individual cost per calf per day.

$$\frac{\$2,258.97 \text{ Total Cost}}{1,200 \text{ calves}} = \$1.882$$

The two cost numbers equated on an individual calf per day basis are nearly equal, similar to the total cost equations. Again, the numbers are very close but not equal. This is due to the number of variables that do not stay constant, such as varying components in milk and the number of calves in hutches.

These total cost numbers are based on the fact that Rancho Sierra Vista Dairy is using 100% of milk that is able to be sold. In other words, these numbers do not include the amount of milk that comes from the hospital, also known as waste milk. Every day Rancho Sierra Vista Dairy collects all of the milk that comes from the cows in the hospital. As mentioned earlier, this milk is unable to be sold, but it is acceptable to be fed to the calves. Normally the waste milk is sold to a calf ranch at a discounted price. In this scenario at Rancho Sierra Vista Dairy, they collect the waste milk and feed it. The amount of milk varies from day to day because there are cows that move in and out of the hospital depending on their health status. Twice a day the cows in the hospital are milked. On average, the hospital produces about 200 gallons every day. This means that 200 calves are able to be fed daily from the hospital milk. Almost 20% of the milk needed to feed all of the calves comes from the hospital milk. Therefore, the total costs would reduce by 20% because that's 200 gallons less being drawn out of the tank. 200 gallons translates into 1,720 pounds of milk. 1,720 pounds of milk means that it is 17.20 units of milk (1 unit = 100 pounds of milk). As mentioned before, 100 pounds of milk is at a price of \$22.11 for Rancho Sierra Vista Dairy.

$$(17.20 \text{ units of milk}) \times (\$22.11 \text{ milk price}) = \$380.292$$

The above equation demonstrates the amount of money saved, \$380.29, by feeding the given amount of hospital milk. As a result of this, the total cost for feeding raw whole milk would be reduced to less than 2,000 dollars. Therefore, it is about 150 dollars more to feed raw whole milk per day, compared to feeding powdered milk.

COST OVERVIEW

	Powdered Milk*	Fluid Milk Analysis**	Milk Solids Analysis**
Cost/Calf/Day	\$1.456	\$1.898	\$1.882
Total Cost/Day (1,000 calves)	\$1,458.83	\$1,898.00	\$1,882.5
Total Cost/Day (1,200 calves)	\$1,750.6	\$2,277.6	\$2,258.97

ADJUSTED COST OVERVIEW

	Powdered Milk*	Fluid Milk Analysis**	Milk Solids Analysis**
Cost/Calf/Day	\$1.456	\$1.581	\$1.565
Total Cost/Day (1,000 calves)	\$1,458.83	\$1,517.71	\$1,502.28
Total Cost/Day (1,200 calves)	\$1,750.6	\$1,897.31	\$1,878.68

*Based on powdered milk price \$64.55 for 50 lb. bag

**Based on milk price \$22.11 per 100 lb. milk

RESULTS

Rancho Sierra Vista Dairy made the switch from feeding their calves powdered milk to fresh raw whole milk from the tank. This decision was made hinging on the fact the calves will grow faster with a higher component feed product. Many studies have been done and researchers have agreed upon that the more nutrient-rich milk will result in faster growth. This is important because of the positive long-term effects. Feeding calves raw milk does not instantly create a dramatic change in the calves - it is very long process. This long process starts from day one all the way until that animal is full-grown.

In order to monitor the differences in the two groups and their growth, every calf has to be weighed on the day of birth. Rancho Sierra Vista Dairy started weighing their newborn calves near the beginning of November. All of these calves were fed powdered milk every day until the day they are weighed out and moved out of the hutches. The dairy kept this process going until February 15. This is when they made the official switch to feeding calves raw milk. They continued to weigh each and every calf. They also kept every other factor consistent. In other words, the only change they made was the type of milk being fed. As a result of this, there are differences in the weight numbers of the two different groups only because of the component differences in the milk. From the powdered milk group of calves, there were over 1,100 calves that had their in-weights and out-weights recorded. With these two numbers available, as well as the number of days in the hutch (DHUT), the Average Daily Gain (ADG) is possible to find out. Out of all 1,101 calves fed powdered milk, the overall ADG was 1.452. This number represents

the average of all of these calves. There were calves that were gaining about two pounds per day in the hutch. Then there were calves that gained less than one pound per day.

Total	Overall ADG
1101	1.452

Also included in this average is a mixture of different types of calves. As mentioned earlier, there are three main groups of calves - Rancho Sierra Vista Dairy heifers, Rancho Sierra Vista Dairy steers, and Double J Dairy steers. There is a significant difference in the growth patterns between male and female growth. Below are the ADG's from the three different groups as well as the number of calves for each group.

	RSV Heifers	RSV Steers	DJ Steers	Total
ADG	1.425	1.466	1.468	1.452
Count	390	484	227	1101

As displayed above, there are noticeable differences in the ADG's between the heifers and the steers. Steers are generally larger than heifers during this stage of life and they also grow faster. It is beneficial to separate the different groups to not get confused by the overall average. The steers had higher ADG's that bumped up the overall average. High ADG is great for both heifers and steers, but the heifers are the group that should be the most focused on. This is because all of the research done for future milk production. For Rancho Sierra Vista Dairy, both heifers and steers are important. They raise these steers until they reach a certain weight, then the steers are sold for beef.

One other factor that is very important is how long the calves stay in the hutches. The longer the calves are in the hutches, the more days the calves are being fed milk. This is critical because calves that stay longer in the hutches generally have a higher ADG. Below is a breakdown of all of the powdered milk fed calves and the number of days in the hutch. There are four different groups organized by the number of days in the hutch. Also in the table, there is the ADG that corresponds to each group.

	DHUT <= 80	DHUT 81-85	DHUT 86-90	DHUT 91+
Count	222	270	496	114
ADG	1.386	1.448	1.468	1.520

As displayed above, there is upward trend of the ADG depending on how long the calves are in the hutches. This is a good thing because the calves are gaining a lot of weight towards the end of their time in the hutches. Over 86 days in the hutch is above the overall average ADG. Although the higher ADG's look good on paper, typically the calves need to be moved out of the hutches eventually. They cannot stay in the hutches for too long because they need to increase their grain intake to develop their stomachs. Rancho Sierra Vista Dairy moves the calves out of the hutches when there is enough space in the pens. Each time they weigh out the calves, about once every two weeks, there are about 100 to 150 calves. Because of this, not every calf spends the same amount of time as the others. There is some small variation in the days in hutch. Rancho Sierra Vista Dairy has done an excellent job at keeping things consistent for the number of days in hutch, especially between the powdered milk calves and the raw whole milk calves. Below are the averages of days in hutch (DHUT) of both groups.

	Raw Whole Milk	Powdered Milk
Average DHUT	82.239	84.828

Both groups have spent almost the same amount of time in the hutches. More importantly, there was not one group that had a significant amount of more days than the other. If that was the case, the numbers would've been thrown off because the longer the calves are in the hutches. The table earlier showed that there were higher ADG's when they spent more days in the hutch. Like the powdered milk fed calves, the calves being fed raw whole milk experienced similar patterns in terms of ADG's and days in hutch. The longer the calves stay in the hutch and continue consuming milk more weight is gained.

	DHUT <= 80	DHUT 81-85	DHUT 86-90	DHUT 91+
Count	119	153	105	0
ADG	1.429	1.534	1.554	0

Although the powdered milk calves spent almost two more days than the raw whole milk calves, the powdered calves had lower ADG's. The calves being fed raw whole milk had higher ADG's in every category and group. This is because of the higher nutrient milk that was provided for the calves. Similar to above, displayed below is a total overview of the different groups of calves and their ADG's.

	RSV Heifers	RSV Steers	DJ Steers	Total
ADG	1.459	1.517	1.535	1.506
Count	107	143	127	377

It is clear that there is an improvement in the growth of these calves just by switching what is fed. Higher nutrient milk will result in more growth in Holstein calves. The Rancho Sierra Vista heifers fed the raw whole milk had an average of 1.459 pounds of Average Daily Gain. The same group of calves being fed the powdered milk had an ADG of 1.425. The number 1.459 of ADG with the heifers is quite the difference compared to the powdered milk group of heifers. Typically the steers will grow faster. However, the heifers being fed raw whole milk grew just as fast as the steers being fed powdered milk. In fact, 1.459 is higher than the ADG average of all of the powdered milk fed calves. Also, the two groups of steers experienced much improved growth as well. These results support the claims made by all of the qualified researchers. The higher percentages in protein and butterfat resulted in the improved growth of these calves.

On average, the raw whole milk fed calves were about five pounds heavier when they were weighed out and moved out of the hutches. This is because of the difference in ADG's ($1.506 - 1.452 = 0.054$) multiplied by the average days in the hutch ($84 \times 0.054 = 4.536$). This number can be translated into percent of bodyweight difference. The additional 4.536 pounds is about 2.5% increase in bodyweight. The increase in bodyweight is not an overwhelming number, but it definitely contributes to the amount of money Rancho Sierra Vista Dairy is saving in feed costs. The calves were heavier in less time in the hutches. This means that Rancho Sierra Vista

Dairy could essentially move out the calves two days earlier. In terms of feed costs, this would mean lower costs to feed all of the calves.

It is evident that the raw whole milk made an impact in the growth of the calves at Rancho Sierra Vista Dairy. Due to the rapid growth, they are able to save some of the feed costs. Although it is beneficial to cut costs, this is not the main reason why Rancho Sierra Vista Dairy decided to make a change in the feeding of their calves. Rancho Sierra Vista Dairy wanted their calves to consume a higher nutrient milk product for increased growth at a young age to secure a productive future for these animals. Increased growth at young age sets up these heifers to be bred earlier, which basically means that they will begin their milk production earlier. Also, studies show that there will be more productive lactations, in terms of the amount of milk produced. As a result of this, Rancho Sierra Vista Dairy will become more efficient overall.

There is only one question that remains, how productive will these Holstein heifers be in the future? The total results of this experiment depend on the productivity in the future. This is something will not be able to be observed until two years from now when these heifers start their milk production. Given the research and studies mentioned earlier and the results of the growth of these calves, everything should work out as planned. In other words, these future milk-producing cows are expected to produce more. If this is the case, the switch to feeding raw whole milk at a young age is well worth it. If these cows do not produce as expected, there might need to be some reconsidering if the milk price stays this favorable.

It is costly to feed such a valuable product, especially when that milk can be sold for revenue. The milk price will not always remain this high though. When the price of milk starts to fall back down a little lower, as market trends show, Rancho Sierra Vista Dairy will have lower feed costs. With these lower feed costs, they will still be getting the same results when feeding raw whole milk. This will be relieving for Rancho Sierra Vista Dairy because they started feeding raw whole milk when it was at a high price. If there is a lower price, it will be bittersweet for Rancho Sierra Vista Dairy. However, in terms of their calf operation and the costs that go along with it, they will be happy they made the switch. Their calves are now set up with a system that will make the whole dairy more efficient.

Overall, this looks to be a good move by Rancho Sierra Vista Dairy. Prior to this project, they were confident in the ability of their calves to grow faster with their milk at a reasonable cost. So far the results of them feeding raw whole milk to their calves are as they expected. The calves are growing at a fast rate, showing definite signs of improvement compared to before. This is just the beginning for Rancho Sierra Vista Dairy. Over time they will start to see the main reason why they made this decision. With the research that has been done, it is safe to say Rancho Sierra Vista Dairy will undoubtedly see these results in the years to come.

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